A SECURE METHOD OF DECIDING ON A GIVEN STATE OF A COMMUNICATION CHANNEL FOR A TRANSMISSION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on French Patent Application No. 02 08 112 filed June 28, 2002, the disclosure of which is hereby incorporated by reference thereto in its entirety, and the priority of which is hereby claimed under 35 U.S.C. §119.

BACKGROUND OF THE INVENTION

Field of the invention

The field of the invention is that of telecommunications. To be more precise, the present invention relates to a secure method of deciding on a given state of a communication channel in a data decompression device.

The invention also relates to a data transmission system.

Description of the prior art

Figure 1 shows a prior art satellite data transmission network which includes a satellite 11 and a communication resource management center 10 that communicates by radio with the satellite 11. Traffic stations 12, 13 comprising terminals operating in TDMA or SCPC mode also communicate with the satellite 11 and are connected to public or private telephone switching centers 14, 15, usually referred to as a public switched telephone network (PSTN) in the case of a terrestrial network. Each PSTN 14, 15 is connected to a plurality of users 16, 17.

Calls between users 16 and users 17 connected to different traffic stations are set up by the management center 10 which dynamically allocates transmission frequencies (in SCPC operating mode) or time slots of a time frame (in TDMA operation) as a function of connection requests from these users. This is known as demand assignment multiple access (DAMA) and this dynamic allocation of resources optimizes the use of satellite resources.

Thus satellite resources are assigned on demand; when a user requests a call, and if his request can be honored, a satellite channel is set up between the outgoing traffic station to which the requesting user is connected and an incoming traffic station to which the called party is connected. The management center 10 is also informed of the releasing of assigned resources at the end of a call.

The center 10 not only manages satellite frequencies but also the making available of modems in the outgoing and incoming traffic stations for setting up the telephone connections.

Operation is generally as follows:

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In the SCPC mode of operation, the management center 10 assigns satellite frequencies when it detects line seizure by a user 16 or 17, that line seizure being manifested in an analog signal (at a particular frequency) or a digital signal (line seizure signaling bit or word) transmitted by the user to the management center 10 via the PSTN 12 or 13. The traffic stations 14 and 15 shape the signals sent by the users for transmission to the management center 10 via a modem.

One such frame is shown by way of example in figure 2. The frame 20 comprises 32 time slots IT1 to IT32, each of eight bits, of which the first time slot IT1 is dedicated to particular signaling and synchronization, the time slot IT16 conveys line signaling from the PSTN, and the other time slots are reserved for transmitting payload data (dialing, voice data, etc.) sent by the users for one transmission direction. The users constitute telephones, private branch exchanges or a public telephone network. Each frame has a duration of 125 µs and provides a communication bit rate of 2 Mbit/s.

Figure 3 shows diagrammatically part of the infrastructure of a Global System for Mobile communications (GSM) network. It shows the radio subsystem 21 representing the base station system (BSS) managing the radio transceiver stations. A BSS comprises a base station controller (BSC) 22 and one or more cells and thus one or more base transceiver stations (BTS) 23. The BSC manages the radio resources of the BTS attached to it and the operation and maintenance functions of the base transceiver station. It autonomously executes handover of mobile stations moving around in its coverage area. Furthermore, as shown in figure 3, the BSC has two standardized interfaces, a A-bis interface with the base transceiver stations 23 and an A-ter interface connecting the BSC to a mobile switching center (MSC) 24 via a transcoder rate adapter unit (TRAU) 25. The purpose of this is to convert compressed voice at 13 kbit/s to digitized speech at 64 kbit/s in order to render the speech channels compatible with the MSC. Thus the MSC-BSC coupling is effected at a standard bit rate of 64 kbit/s on the MSC side and of 16 kbit/s on the BSC side, this bit rate comprising the bit rate of the compressed voice at 13 kbit/s plus an additional bit rate consisting of framing and stuffing bits. The interface between the MSC and the TRAU is called the A interface; the interface between the TRAU and the BSC is called the A-ter interface.

The TRAU 25 is compatible with the various signal types transmitted at the A-ter interface, and converts all these signal types to a bit rate of 64 kbit/s. These signals are essentially voice at 16 kbit/s (full rate) or 8 kbit/s (half rate) and signaling

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at 64 kbit/s or 16 kbit/s.

The MSC is the interface between the BSS and a cable network such as a public land mobile network (PLMN) 27. The MSC carries out all operations needed for managing calls involving mobile terminals. To obtain radio coverage of a territory, a mobile network switch controls a set of senders, which explains the presence in Figure 3 of a plurality of A-ter interfaces with other BSS.

The A-bis interface providing the connection between the BTS and the BSC of the system is established via a synchronous interface E1 using G.703 frames (referred to as E1 frames). A portion of each frame carries payload data.

It will be noted that of a GSM network expansion via satellite, in particular as proposed hereinafter, is effected either at the A-bis interface or at the A-ter interface, or possibly at the A interface.

Regardless of which interface is selected for network expansion via satellite, the number of transmission channels used (time slots or subdivisions of time slots) is fixed and depend essentially on the physical configuration of the BSS (number of BTS, number of carriers). On the other hand, at a given time, only some of the transmission channels are active; the number of active channels depends on the signaling to be carried, the number of calls that have been set up, and on the inherent half duplex nature of dialog between parties.

To minimize the bandwidth required for the satellite communication for network expansion via satellite, the telecommunication system considered for the network expansion functions in DAMA mode, i.e. the satellite resources dedicated to the connection at a given time depend on the bit rate of the data to be transmitted, i.e. on the number of active channels within the frames to be transmitted.

The equipment enabling the DAMA technique to be used operates in two different modes:

- either the equipment interprets signaling (for example SS7 signaling) to detect the activation of new transmission channels in order to adapt the assignment of transmission resources accordingly (variation of the band assigned for a given connection); in this case, the signaling is not standard signaling, and having the DAMA operate as a function of the signaling carried would be complicated and would depend on the equipment supplier, the A-bis interface between the BSC and the BTS not being standardized,

- or the equipment is at the Ethernet, ATM, or even Frame Relay interface; in this case, the DAMA process functions more simply, because it takes the average bit rate

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on the transmission channel as its base for adjusting transmission resource assignment. Note that in the present case the bit rate is invariant, because it is independent of the activity of the channels to be transmitted via the satellite, and is typically equal to 8 × 16 kbit/s per carrier transmitted by the BTS.

5   This second version of DAMA, based on measuring or detecting bit rate variations, is preferred because it avoids having to interpret the signaling carried at the remote interface in order to vary the satellite band assignment. However, because the network expansion interface is not directly compatible with the transmission equipment of the system, an intermediate device known as a transcoder is used.

10   A two-fold requirement is imposed for the transcoder: firstly, it must be able to extract from synchronous frames the payload data corresponding to active transmission channels, and only those channels, and then encapsulate them in Ethernet frames, IP packets or ATM cells. These elements are fed to the transmission equipment of the BSC, which can therefore offer the benefit of DAMA.

15   Moreover, the transcoder must also be able to restore synchronism at the end of the transmission system, in that the process introduced, based on extracting payload data from synchronous frames and encapsulation, completely breaks the original frame sequence. Consequently, the transcoder must be able to reconstitute the frames identically as they existed at the source.

20   To obtain the benefit of the DAMA functions offered by the transmission equipment, the E1 frames must be converted into Ethernet frames, IP packets, or an ATM stream. Prior art transcoders can handle E1-Ethernet or E1-IP adaptation, or E1-ATM adaptation if there is no compression of the frames E1 to be transmitted. Whether the frames E1 carry valid data or not, the resultant bit rate is constant; thus

25   these transcoders cannot reduce the satellite bandwidth as a function of the effective activity of the GSM network transmission channels; the reason these transcoders ignore the real activity of the transmitted channels is associated with the fact that they constitute interface conversion solutions and do not analyze the content of the frame.

To eliminate the drawbacks cited above, the Applicant has this day filed a

30   French patent application (referred to hereinafter as the INV1 application) with the French title "Compresseur, décompresseur, bloc de données et procédé de gestion de ressources" [translated as "Compressor, decompressor, data block and resource management method"]. The INV1 application describes a compressor for compressing data from input data frames. According to the invention, the compressor

35   detects the bits (carrying a communication channel) that vary from one frame to

another (are "active") and transmits only these in the data block. The block also contains a state code locating the "active" data in the original frame in order to be able to reconstitute it.

The compression process takes place within an analysis window that contains a fixed number of input frames (for example 16, 32, 64 or 128 input frames).

A channel is treated as non-active, or static, as soon as the same pattern, as regards its content, recurs periodically during the analysis window. For example, this kind of situation arises when, for a given channel, i.e. for a given bit, the pattern 1110 is reproduced by input frame groups in input frames. This pattern is identified as a reference pattern for the bit considered. If the analysis window contains 16 frames (has a length of 16 frames), for example, the pattern 1110 occurs four times in succession in the analysis window (i.e. there are four groups).

At the other end of the data compression system, each compressed data block is decompressed using an active channel descriptor inserted into the header of the block in order to restore the original structure of the input frames, by replacing each channel at the place it occupied before compression. In this way, N output frames identical to the input frames are reconstituted from a compressed data block; for the non-active channels, the decompression device functions by repeating the reference state all along the current window. The reference state for each static channel is obtained from a reference pattern that is transmitted periodically, for example between two data blocks.

However, despite the ingenuity of the principle explained above, it can suffer seriously from errors in transmitting bits included in the static bit groups of the analysis window.

Returning to the above example, if the analysis window contains the following sequence of bits:

1110111011101110

for a given channel and over 16 frames, then, the content of that channel reproducing the content of the reference state for this bit, which is 1110, during 16 frames, the bit will be considered static and the decompression device will act accordingly.

However, following a transmission error, if at least one of the 16 bits is transmitted incorrectly, the reference state of the channel in question is no longer identically reproduced and the decompression device will analyze it as an active bit,

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although this is not the case in reality.

Thus the invention aims to solve this major problem.

SUMMARY OF THE INVENTION

To this end, an object of the invention is to provide a secure method of deciding on the 0 or 1 state of each bit of a pattern repeated by a static communication channel in a data decompression device adapted to decompress a block of data including a group of data from a set of data frames compressed by a data compression device, said group including all the active channels of the set, it being understood that the frames have a structure defined in accordance with a plurality of time slots, each time slot of a first group of time slots is divided into a plurality of information bits carrying a respective communication channel, and the active state, respectively the static state, of each channel is assigned if the comparison of the content of this channel in the N bits compared between the N frames of a reference pattern with the corresponding N bits of the N frames of the analysis window, where applicable repeated L times, shows a variation in the content for at least one of the bits, respectively a stability of the content for all of the N bits, where N is an integer greater than or equal to 1, which method includes:

- a step of transmitting a descriptor specifying the static or active state of the transmission channel,

- a step of transmitting the content of the channel that has gone to the static state on the L*N frames of the analysis window after it goes to the static state,

- a step of statistical analysis, over the analysis window carrying the L*N frames after the channel changes to the static state, of the state of each bit of the pattern repeated by said channel, based on a majority vote of the states obtained for each bit of the channel considered on the L groups of frames in the analysis window, which statistical analysis is intended to reconstitute the original state of each bit of the pattern.

Thus, because the decision is based on a majority vote of the static bits, the decision for a given channel to go to the static state is free of errors caused by errors in the transmission of a few of the disturbed bits.

In one embodiment, a counter is associated with each bit carried by said channel and the statistical analysis step includes a step of initializing the counter at the start of the analysis window, a convention for incrementing or decrementing the counter being established in accordance with the successive binary values taken by each bit of the channel within the L groups, the sign of the final value of the counter

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deciding on the state present in the majority in the L groups.

In one embodiment, the number of bit transmission errors corresponding to the specified channel is identified by the following equation in which NT = L*N corresponds to the number of frames contributing to the composition of a frame:

5 $$Ne = (1 + (NT/N) - |X|) / 2.$$

In one embodiment, the number of analysis windows used for the process of repeating the static pattern as a function of the existing transmission quality between the compression device and the decompression device is varied.

In one embodiment, information is integrated into a header of the block of 10 data to specify the number of analysis windows used.

In one embodiment, the information includes:

- 0 if error detector means of the type comprising a demodulator measure a link quality below a first threshold,

- 1 if the error detector means measure a link quality above the first
15 threshold,

- a number greater than 2 whose size increases if the measured error rate exceeds a particular value (x) of the ratio NT/N.

The invention also provides a data transmission system comprising a compression device and a decompression device, which is adapted to implement the
20 method according to the invention.

Other features and advantages of the invention will become apparent on reading the following description of embodiments of the invention, given by way of non-limiting illustration, and examining the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS
25 Figure 1, already described, represents a prior art satellite data transmission network.

Figure 2, already described, shows a prior art frame fed to a traffic station from a switching center.

Figure 3, already described, shows diagrammatically a portion of the
30 infrastructure of a GSM network comprising the radio subsystem.

Figure 4 shows a first embodiment of a satellite data transmission system according to the invention.

Figure 5 shows a satellite signal transceiver in a GSM cellular network infrastructure.
35 Figure 6 shows the frame structure to be transmitted at the A-bis or A-ter

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interface.

Figure 6' shows a signal transceiver comprising a compressor and a decompressor conforming to one embodiment of the invention described in the INV1 priority patent application FR No. 01 11 048 filed by the Applicant, hereinafter referred to as the INV1 priority application, whose content is incorporated into the present application.

Figure 7 shows a frame compression device conforming to one embodiment of the invention of the INV1 priority application.

Figure 8 shows the comparison principle conforming to one embodiment of the invention of the INV1 priority application for a given time slot of its content over a plurality of consecutive frames.

Figure 9 shows the structure of a block of data delivered by the restitution block of the compressor in one embodiment of the invention of the INV1 priority application.

Figure 10 shows the traffic variations at a traffic station for 16 simultaneous voice calls.

Figure 11 shows a device for decompressing blocks of data conforming to one embodiment of the invention of the INV1 priority application.

Figure 12 shows a variant of the figure 11 data block decompression device.

Figure 13 shows diagrammatically the operating principle of the compression method according to the invention of INV1 .

Figure 14 shows one embodiment of the compression device according to the invention of INV1.

Figure 15 shows one embodiment of the decompression device according to the invention of INV1.

Figure 16 shows one embodiment of a compressed frame or compressed data block according to the invention of INV1.

Figures 17a and 17b show error configurations occurring in the compressed frame of INV1.

Figure 18 is a diagram showing the sampling period of the reference pattern and its transmission in the system, the successive states of a given channel and the times at which the compression method according to INV1 is triggered according to INV1.

Figure 19 is the equivalent diagram in accordance with the present invention.

Figure 20 shows one embodiment of a statistical analysis carried out in accordance with the invention using a set of counters.

Figure 21 shows the evolution over time of one of these counters with no transmission errors on the associated channel.

5 Figure 22 shows the evolution of the same counter with two transmission errors on the associated channel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In this application, items having identical or equivalent functions carry the same reference numbers.

10 It will be noted that, notwithstanding the incorporation of the content of the INV1 priority application and of that of INV1, to clarify the background of the invention and because of their great interest, the invention of the present application is described only with reference to figure 18 onwards.

Figure 4 repeats the components of the figure 1 telecommunication system.
15 The system comprises two telephone switching centers 14, 15 each connected to a plurality of users 16, 17 and to a respective traffic station 12, 13. The switching centers supply 2 Mbit/s frames, as shown in figure 2, and are shown in more precise detail in figure 6, which relates to figure 5. Each traffic station 12, 13 is connected to a signal transceiver 26 connected to a respective satellite antenna 28, 29.

20 Figure 5 shows how the device 26 fits into a GSM cellular network infrastructure. It will be noted that the device 26 can be included in the BSC 22 or even implemented at the A-ter interface.

The device 26 is shown in more detail in figure 6'. It includes a first input/output pair connected to the interface E1 connected to the BSC 22. This
25 input/output pair is connected to a device 30 for compressing/decompressing frames that is described in more detail later. The device is also connected to a modem 31 for full duplex sending and receiving of time slots in the TDMA transmission mode. The modem 31 is connected to the input/output of a signal radio processor unit 32 connected to the respective antenna 28, 29.

30 The system further includes, as in the prior art, a resource management center 10 and a satellite 11 through which calls between the stations pass.

A first input of the device 26 is connected to a first input of the first pair of the device 30 connected to an input of a device 301 for compressing frames and supplying an output signal at a first output of the device 30 to the modem 31; a
35 second input of the device 30 connects the modem to a device 302 of the device 30

for decompressing frames delivering a decompressed frame signal to an output of the device 26 connected to the BSC. Hereinafter, for conciseness, the device for compressing frames will be referred to as a compressor and the device for decompressing frames will be referred to as a decompressor.

5   The compressor 301 compresses frames to be transmitted and adapts the format of the resulting blocks of data to the interface offered by the modem 31 in sending mode, namely an Ethernet, IP or ATM interface.

The decompressor 302 handles adaptation to the interface offered by the modem 31 in receive mode (which is generally identical to that used on the sending
10   modem side) and resconstitution of the frames supplied to the input of the compressor.

Figure 6 shows the typical structure of a frame 60 to be transmitted at the interface A-bis or A-ter of GSM cellular networks. It will be noted that the present invention is not limited to this kind of interface and encompasses any other type of
15   interface, in particular those relating to non-cellular networks.

Each frame is divided into a fixed number of time slots, in this instance 32 time slots for E1 frames conforming to the ITU-T's G.703/G.704 recommendations, each time slot carrying one byte. The time slot 0 is reserved for synchronizing the transmission of frames, with a view to synchronizing the reception of frames at the
20   destination equipment end. The frame frequency is generally 8 kHz, conveying 31×64 kHz channels, at the rate of one channel per slot.

In the present context of extension of cellular networks via satellite, each byte breaks down as follows:

- each byte comprises 4 nibbles (each consisting of a sample on 2 bits), and
25   each nibble carries one 16 kbit/s channel; this is the case in particular for the transmission of the 16 kbit/s compressed channel at the A-bis and A-ter interfaces;

- each byte transports eight half rate compressed voice channels, and each bit therefore corresponds to one voice channel;

- the byte is not subdivided, which is the case transmitting data using the
30   General Packet Radio Service (GPRS), using 64 kbit/s user data channels, or for transmitting signaling;

- other, alternative forms can exist: for example two 32 kbit/s channels or one 32 kbit/s channels plus two 16 kbit/s channels, etc.

Figure 7 shows a compressor 301 conforming to one embodiment of the
35   invention of the INV1 priority application.

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The operation of the compressor is described hereinafter:

In a first time period, it extracts the content of each frame. For this, it synchronizes to the reference time slot 0 and extracts the data present in the subsequent time slots.

5 It then compresses the extracted data within the frame. This process depends on the structure of each time slot. Two approaches to this are envisaged:

- either the structure of the frame (number of time slots used and their position in the frame) and the structure of each time slot are defined by a configuration procedure: four 16 kbit/s channels (nibble structure), then eight 8 kbit/s

10 channels (bit structure), then one 64 kbit/s channel, etc.,

- or the compressor determines the structure of each time slot for itself by means of a learning process, through statistically analyzing the evolution of each bit and correlating it with the evolution of adjoining bits, in order to identify correlations in the changes of state; it is agreed that the configuration of the structure of the

15 frames transmitted generally does not evolve, and that a learning procedure can therefore be used to avoid having to configure the compressor as a function of how it is used.

Figure 7 shows a device 301 for compressing frames conforming to one embodiment of the invention of the INV1 priority application. The compression

20 principle used by the compressor is the following: the structure of the time slot being known, the compressor compares the content of the slot of the current frame to the content of the same slot in the preceding frames. This principle is shown diagrammatically in figure 8, which shows the comparison principle for the reference time slot 2 and over a time period of six frames.

25 The data frames enter via the input 33 of the compressor 301, which is connected to the input of the first input/output pair of the device 26. This input 33 is connected to a frame buffer 34 for storing the current frame and operating in accordance with a First In First Out (FIFO) logic. The output of the buffer 34 is connected to an input of a memory 35 for storing the frame preceding the current

30 frame present in the memory 34. The output of the memory 34 is also connected to an input of an analysis unit 36, which input is connected to a comparison unit 361 in the unit 36. Thus the unit 361 is adapted to compare the current frame with the frame preceding it, which it receives at a second input connected to an output of the memory 35. The analysis unit 36 further includes a unit 362 for detecting state

35 variations whose input is connected to the output of the comparison unit 361 and a

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state machine 363 connected to the output of the detection unit 362 and adapted to determine the active or static state of each of the elements transmitted (for example each of the nibbles transmitted), as described hereinafter. The output of the memory 34 also feeds the current frame to the input of an active element extractor 37 whose input is connected to the output of the state machine 363 of the analysis unit. The output of the state machine is connected in parallel to a state encoder 41 adapted to supply compact active element position identification codes, systematically in operation or on detection of a change of activity state of components of the frame. Finally, the output of the memory 34 is connected to the input of a frame synchronization unit 38 whose output is connected to the input of a frame counter 39. The counter 39 delivers a number specific to the current frame to a first input of a data regrouping unit 40 for constructing blocks of data grouping data specific to the current frame. The number supplied by the counter 39 identifies the current frame. A second input of the grouping unit 40 is connected to the output of the extractor 37 and a third input is connected to the output of the encoder 41.

The grouping unit 40 constructs a block of data using a method that will be described in detail hereinafter and its output feeds the data block to an output buffer 42. A plurality of blocks are preferably concatenated in the memory 42 before transmission to a physical output interface 43 of the compressor 301 handling the adaptation to the type of interface used for the coupling with the sending modem 31 (Ethernet, IP, or ATM).

The compression method used by the compressor includes the following steps:

The analysis unit 36 analyzes variations in the content, based on the structure of the frame established by the configuration procedure in the example described here (for example nibble by nibble for a frame structured in nibbles), and detects state variations. This is done within the analysis unit by comparing each nibble with the corresponding nibble in at least the preceding frame, the result being supplied to the detection unit 362, which detects and supplies active or static activity states to the machine 363, according to whether there has been any variation in the state of the nibble or not. If a nibble does not vary a fixed number of times, for example three times (which number of times can be much higher, and is configurable in the state machine 363), the state machine 363 informs the unit 40, via the state encoder 41, that the content of this nibble is no longer being updated; the nibble is then considered as being in the static state. The compressor then stops the

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transmission of the nibble concerned.

Conversely, as soon as a nibble changes state after it has been detected as static, the transmission of its content resumes without delay, the state machine transmitting a compact code for activating the state of the nibble to the unit 40 via the state encoder.

The codes which are transmitted to the unit 40 are representative of variations in the state of the elements (the nibbles in this case) and are a function of the structure of those elements. According to one convention (which can obviously be reversed or modified), within a stream of bits representing the state of the elements transmitted, a 1 signals that an element is active and a 0 signals that an element is static; for example, for a pair of consecutive time slots each transporting four nibbles, the following code combination could apply: 1010 1111 (AF in hexadecimal). This sequence is representative of six active nibbles and two inactive nibbles (those assigned the code 0). The code indicative of a change of state is transmitted without delay immediately an element of the frame goes from the static state to the active state.

In order not to overload the frames transmitted with change of state signaling, a time-delay is implemented for indicating a change of one or more elements from the active state to the static state. On the one hand, the compressor has access to a preprogrammed memory 3631 of the state machine 363, which counts at least three frames (for example) to verify that the element considered is identical over the three frames, but additionally the buffer 42 of the compressor holds at least N frames relative to the preceding change of state indication; this spreads out the change of state signaling and prevents overloading the connection.

Conversely, as soon as an element changes from the static state to the active state, the state machine is programmed to transmit the change of state of the frame code immediately.

The change of state code of the frame, or state code, includes all the state codes of the elements carried by the frame, only for the time slots used, these state codes being generated by the method defined above.

For example, for a frame used to transport two time slots, the code 00AF delivered by the encoder signifies that all the elements of the first time slot are static whereas those of the second time slot are active except for nibbles 2 and 4 (this is above example 1010 1111). Thus the change of state code, called the state code hereinafter, serves as a location indication for the active elements of the frame. This

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state code is supplied by the encoder 41 in the state information at the output of the state machine.

Consequently the nibbles can have two mutually exclusive stable states, respectively static or active, and therefore the grouping unit transmits only the nibbles that have been signaled to it as active, adding stuffing bits to complete the block of data as a function of the constraints of the interface used. These stuffing bits are managed by a stuffing bit manager 401 internal to the grouping unit. The stuffing bits are explained in more detail hereinafter. It will be noted that instead of useless stuffing information, it is possible to use this space in the frame to repeat data critical for the efficient reconstitution of frames, such as the state code or the frame number.

Figure 9 shows the structure of a block of data 44 delivered by the grouping unit 40 of the compressor. The block 44 comprises a block 441 of compressed data including the nibbles to be transmitted and a state code of the current frame, for example 00AF. This state code is representative of the position of the active elements within the frame considered.

To signal a change of state to the decompression device at the other end of the transmission system (which decompression device is explained hereinafter), the compressor adds to the state code of the current frame, for example 00AF, via the encoder 41 or the unit 40, a specific code 443 signaling the presence of a state code 442 within the block, which signifies that the data block transmitted corresponds to a change of state. In a variant, specific codes as specified hereinabove accompanying the state code of the current frame are not added, but the decompressor detects the addition of the state code by analyzing the length of the block of data received. As soon as the block has a different length, the decompressor can deduce that a state code is present at the end of the block.

Moreover, a frame number 444 is added at the head of the block of compressed data, to guarantee synchronization of the decompression of the data and the taking into account of loss of data block situations in the transmission system. This frame number is counted modulo the capacity of the counter used for this purpose (for example 8 bits or 16 bits).

The resulting data block is encapsulated in the Ethernet frame, the IP packet, or the ATM cell, as a function of the transmission mode adopted.

A plurality of blocks are preferably concatenated in the buffer 42 before encapsulation in order to reduce the bit rate overhead associated with encapsulation.

The physical output interface 43 handles the adaptation to the type of

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interface used for the coupling with the sending modem (Ethernet, IP, ATM).

It will be noted that the advantage of choosing the Internet Protocol (IP) over Ethernet is that it allows the inclusion of optimized routing functions and automatic rerouting functions in the event of an error on a connection.

5 There follows a more detailed explanation of the benefit of the stuffing bits referred to hereinabove. To this end, figure 10 shows the variations in traffic at a traffic station for 16 simultaneous voice calls, allowing for periods of silence. These variations follow a statistical profile: the probability of the 16 channels being active simultaneously is very low, and likewise the probability of the 16 channels being 10 simultaneously silent; on average, eight of the 16 channels are active.

Because the compressor is connected to a satellite transmission system including a DAMA function, satellite resources are assigned at a slow rate, for example every 1.6 seconds, although during those 1.6 seconds a number of parties will go from being silent to speaking, although there will not necessarily be as many 15 who go from speaking to silent, which explains the supplementary margin of almost 50% between the assignment of channels by the system to the traffic station considered and the channels effectively used at the latter. Because the resource assignment system cannot usually allow for a margin automatically, the compressor adds margin bits to simulate surplus occupation of transmission resources relative to 20 its actual requirements. The supplementary bits not used to transmit payload data are used to impart redundancy to the most critical information, for example a state code or a frame number. On the other hand, immediately the decompression device has to transmit more elements than in the preceding cycle, it uses the margin bits to transmit them, to the detriment of transmission of redundant information, the status 25 code signaling which new elements are active. This process based on the use of significant margin bits smoothes the load of the link used and therefore adapts the compression/decompression device according to the invention of the priority application (INV1) to the inertia of the resource assignment mechanism used in the conventional way, whilst preventing transmitting bits of no utility. It is to be noted that 30 the shorter the resource assignment cycle, the smaller the margin can be. If the margin is reduced to the point that it is not possible to transmit a state code or a complete frame number, an advantageous solution consists in multiplexing this redundant information over a plurality of consecutive blocks of data, spacing the cyclic repetitions of this information by a repetition boundary indicator, and 35 considering the information multiplexed in this way to apply to the block carrying the

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repetition boundary indicator.

The role of the DAMA function being to assure dynamic sharing of the band assigned as a function of the current requirements of each station, concerning N stations with a balanced current traffic, with the aim of simplification, with 16 calls at each station, a considerable statistical multiplexing gain is achieved if N is relatively high (at least 10).

If N = 1, the resources reserved for the 16 calls are strictly equal to the handling of the 16 calls, i.e. 16 × 16 kbit/s (a call necessitating 16 kbit/s at the A-bis interface). On the other hand, for a high value of N (greater than 10), the ideal case is approximated, which corresponds to the theoretical sufficiency of the 50% reservation of the total band for a station, i.e. 8 × 16 kbit/s per station, or 10 × 8 × 16 kbit/s for all of the ten stations in a given direction, this quantity having to be doubled for both directions.

Rather than establishing a static reservation of resources for each station, resources are assigned dynamically.

With the compressor/decompressor according to the invention of the INV1 priority application, the function for detecting the activity of the nibbles is used to inform the resource management center 10 of the current requirements of the stations. In this example resources are assigned every 1.6 seconds and the current assignment of resources is based on the traffic statistics of the preceding 1.6 seconds cycle.

On the basis of this information on current requirements supplied by the compressor/decompressor according to the invention of the INV1 priority application, the resource center artificially increases the size of the packets transmitted by adding supplementary bits to each packet transmitted to have a sufficient resource margin.

For example, if the current requirement of a station is to transmit 50 bytes every 2.5 ms, 10 supplementary bytes are added, for example, so as not to lose nibbles in transmission if the number of active nibbles detected increases by 20% before the next assignment of resources. If this precaution of reserving a supplementary margin is not taken, the sending modem used for the transmission becomes saturated and rejects surplus packets (relative to the transmission capacity assigned to it for the current cycle) that it is not able to transmit.

The information of the supplementary bits forming said supplementary bytes that complement the transmission packets can be of two types:

- either stuffing information, which is not pertinent to the transmission of

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data, and only intended to provide a bit rate margin for the reasons cited above,

- or payload information, intended to repeat the data that is most critical for transmission: state code, frame number and possibly header bits.

Both types of information may be combined.

It will be noted that repeating the state code may prove highly pertinent in that the loss or incorrect reception of the state code by the destination equipment could disturb the frame reconstruction process, which would be reflected in an offsetting of the nibbles within the reconstructed frame.

The process just described is referred to as level 1 compression. Level 2 compression complements it, using identical signaling and a state code analogous to the state code described for level 1. It functions by identifying the type of content conveyed by the transmission channel considered. For a 16 kbit/s compressed channel, each call is time-division multiplexed at the rate of one nibble per frame. The time-division multiplexing is itself structured in frames, for examples frames of 320 bits every 20 ms. During a call, each party is alternately active or silent. In a manner that is not specific to the device considered here, during periods of silence, the transmission of frames continues but an indicator in the frame shows that the frame is not active. Level 2 compression uses this indicator to suspend the transmission of data relating to compressed voice and to transmit only the payload elements of the 320 bit frame. During the transmission of payload information, the bit corresponding to the position of the element considered in the input frame of the compression device is active within the level 2 state code, and the bit is reset to the inactive state as soon as the payload information has been transmitted. This process increases the effectiveness of the level 1 compression device through extending it to interpret non-static elements including non-payload data.

Figure 11 shows in a detail a decompression device or decompressor 302 conforming to one embodiment of the invention of the INV1 priority application. An input connected to the receiving modem 31 is connected to a physical interface 45 handling adaptation of the frames (Ethernet, IP, or ATM) to the format of the compressed data blocks using the compression method already explained.

The output of the interface 45 is connected to the input of an FIFO buffer register 46 storing the received blocks of data.

A first output of the register 46 is connected to an extractor 47 for extracting a frame number 444, a second output is connected to means 48 for inserting active elements of the current frame, and a third output is connected to a state code

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detector 49.

A frame counter 50 internal to the decompressor is initialized when the connection is set up, with a negative offset relative to the number of the received frame. This is intended to prevent a famine caused by the frames received being delayed relative to the value of the counter.

A comparator 501 compares the value of the number of frames in the extractor 47 and the counter 50. If the value of the counter is identical to the frame number associated with the block present in the buffer register 46, the comparator commands a memory 51 containing the preceding frame to deliver it to an input of the inserter means 48.

The state code detector 49 detects the state code associated with the received block of data and feeds it to the input of a state register 52 whose output is connected to another input of the inserter means 48.

Finally, the memory register 46 delivers the block of received data to a third input of the inserter means 48. Thus, if the frame and frame counter numbers are identical, the inserter means 48 reconstitute the current frame from the repeated preceding frame in the memory 51, replacing the elements signaled as active by the values contained in the block of received data, and on the basis of the information signaling the positions of the active elements delivered by the state register 52.

The reconstituted frame is then delivered to a physical interface 53 handling the adaptation of the blocks of data to the format of the frames at the A-bis interface.

Particular attention must be given to the fact that the spirit of the invention of the INV1 priority application can be extended to higher data levels, as explained hereinafter:

the data carried in the frames to be compressed is generally itself encapsulated in frames with a proprietary or non-proprietary format. The compression/decompression method can be extended, in accordance with the same principle, to compressing data within frames. The objective of such extension is to introduce an even higher compression gain by eliminating all superfluous data.

One example of this is the encapsulation of a 9.6 kbit/s user voice channel into a 16 kbits frame by adding synchronization, stuffing and signaling bits. The additional compression method is adapted to eliminate the synchronization and stuffing bits and to retain only the signaling bits (state codes, etc.), which have a dynamic character, in the sense given previously by the detection of active elements.

The synchronization of the reconstitution of the original frames by detecting

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the boundary between the transmitted blocks of data is implicit.

Of particular benefit is the embodiment of the compression/decompression method according to the invention of the INV1 priority application as described hereinafter, consisting in an automatic change to non-compressed mode:

5 The bandwidth improvement is evaluated continuously. Immediately the bit rate of the average output flow of the nibble compressor exceeds that of the average input flow, the compression device is bypassed, synchronously with a frame boundary, and an indicator is transmitted to the decompressor to deactivate the decompression mechanism on the decompressor side. Conversely, immediately the

10 average compressed flow relative to the incident flow falls below a particular threshold, the compression/decompression device is reactivated.

The threshold is intended to prevent untimely switching from compressed mode to uncompressed mode, in particular if the load in terms of the frames to be transmitted is close to saturation.

15 To avoid any disturbance of the satellite link that could be reflected in a loss of information, the information transmitted being degraded, or even interference information being added, leading to interference with the reconstitution of frames, the following provisions are considered, and can be applied individually or in combination:

20 - automatically changing to uncompressed mode as soon as the quality of the connection becomes critical (which involves monitoring the E_b/N_0 or the BER) and/or using error detection based on the CRC associated with each Ethernet frame, for example,

- adding cyclic redundancy check codes to the most critical information, in

25 particular the state code, to achieve correct recovery of that information,

- repeating the state code,

- systematically transmitting the state code as soon as the quality of the connection falls below a particular threshold or immediately an error is detected (frame number sequence error or CRC error),

30 - sending the state code at a fast rate if the quality of the connection is degraded,

- monitoring the frame number associated with the received block of data, to detect sequence breaks related in particular to a frame loss, and analyzing the next frame number to correct a transient frame number error.

35 The prior art Intelsat Business Services (IBS) frame used for satellite

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transmission has the type of frame structure shown in figure 6. IBS frame transmission is very widely used, as it offers the possibility of transmitting N × 64 kbit/s, where N is established as a function of the actual requirement of the network operator. However, IBS modems do not integrate a function for dynamically varying the bit rate of N × 64 kbit/s as a function of the content to be transmitted.

In one embodiment, the compression device 30 divides the traffic between two or more of its outputs, each output offering a fixed bit rate, activated as a function of the resulting load after compression by the compressor 301 in the method described above. Immediately the compressed bit rate exceeds the bit rate reserved on the first channel, for example 5 × 64 kbit/s, a portion of the traffic is offloaded onto a second channel, for example at 2 × 64 kbit/s, and immediately that second channel is saturated in turn, the second channel is switched to a third channel, for example at 4 × 64 kbit/s, and so on, switching the surplus traffic between the channels 2 and 3 without interrupting transmission but offloading the traffic from the permanent channel to the resulting additional channel.

At the receiving end, the original frames are reconstituted by concatenating the blocks of data received via the main channel and the additional channel.

Figure 12 shows a variant 303 of the decompression device 302 from figure 11 that can also and advantageously be used in any public or private IP network. The advantageous functions in this case are: data compression/decompression at levels 1 and 2, frame number addition, decompression with resynchronization of frames at the output, and specific processing in the event of non-reception of the compressed frame at the time at which it should be reconstituted.

The data blocks 44 enter the decompressor 303 via an input 3030. A frame number extractor 304 extracts the numbers of each frame for identifying them. The blocks 44 are fed to a memory (305) for storing the blocks of data. Figure 12 shows six blocks of data characterized by their frame number 444, each represented by a solid block. The first box of each block represents the state code 442 of the block and the subsequent boxes correspond to the compressed data 441.

In figure 12, a dashed line A surrounds in particular the part common to figure 11 for reconstituting the original frames. This has been described and explained already, and will be described again here.

Furthermore, the device 303 comprises a counter initialization circuit 307 receiving the number of the current frame and the number of blocks of data stored in the memory 305.

When the decompression device is initialized, the circuit 307 initializes the counter 50 and synchronizes it to the first frame number received by the decompressor.

Furthermore, synchronization by the initialization circuit is repeated on repeated detection thereafter of discrepancies between the frame numbers received and the current output of the counter.

Operation is as follows: the decompressed frames are intended to be retained in the memory 305 of the decompression device for as long as the frame respective numbers associated with them are not identical to the frame numbers delivered by the local frame counter, allowing for a negative offset to provide some flexibility in the reconstitution of frames and to compensate time fluctuations induced by the transmission system, which often occur in satellite transmission or in terrestrial networks, especially IP networks, although the frames are supposed to be reconstituted at a constant and unchanging rate. Immediately a situation of identity arises at the comparator 501, the frame for which that identity has occurred is fed to the output of the decompression device.

If no frame corresponds to the number of the frame to be reconstituted at the output of the decompression device, the preceding frame is repeated and/or an error code is generated by a generator 306 for signaling the absence of frames to a telecommunication system management center, not shown.

If the error consisting of the non-identity of the current frame number and the frame number delivered by the local frame counter of the decompression device is repeated over a plurality of consecutive frames, the local frame counter is resynchronized to the frame identifiers received.

The negative offset applied at the output of the frame counter is intended to establish a margin covering the range of time fluctuations induced by the satellite transmission system.

The figure 12 block diagram shows that, instead of using an FIFO like that used in the figure 11 embodiment, a buffer memory is used to reschedule the received blocks of data on the basis of the block number associated with each block of data (the number indicated in the filled in boxes), the initialization circuit initializing the counter on start-up or each time that a repetitive sequence break occurs.

The local counter is initialized as a function of statistics on the variation in the number of blocks present in the buffer by regulating the minimum value so that it is always greater than 1, taking account of a supplementary margin less than the

capacity of the buffer expressed as a maximum number of blocks.

If the number of blocks stored reaches the buffer size expressed as a maximum number of blocks, the generator 306 generates an alarm indicating that abnormal behavior of the network (excessive time fluctuations) has been detected.

5   This variant of the decompression device therefore has the advantages of, firstly, being able to receive blocks of data out of order, thanks to the memory 305, and, secondly, of being able to tolerate transmission time fluctuations, thanks to the offset that is introduced.

What is described hereinafter is directly related to the spirit of the invention
10   of the INV1 application.

The principle of the invention consists in analyzing the content of each channel (carried by two bits in the previous modes, but equally well by 1, 2, 4 or 8 bits, depending on the transmission mode - this is not limiting on the invention); if the channel analyzed is constituted of the consecutive repetition of a reference pattern or
15   reference window throughout an analysis window, it is compressed; for example, for a reference pattern on four bits, corresponding to the state of the bit considered during the last four frames preceding the current analysis window:

- if the reference frame = 1011, for example,

- the channel is compressed if, during the analysis window, the successive
20   content of the channel considered (coded on one bit in this example) is equal to:

a b c d a b c d a b c d a b c d

if at least one bit differs from the cyclic repetition of the reference pattern, the channel is considered active, i.e. not static, and its content is transmitted in its entirety for the current analysis window; for a compressed channel, no data is
25   transmitted apart from an active channel descriptor (ACD), which identifies the position of the active channels within the frame to be reconstituted. The ACD is also referred to as the state code (designated by the reference number 442 in the previous embodiments of the priority application).

Consequently, instead of being based on the state of only one bit per
30   channel, detecting the change to the static state uses the state of the bit during the last N frames preceding the current analysis window.

An embodiment of the compression method in which N = 4 is shown in figure 13.

Note that the first two channels of the analysis window 70 repeat with a
35   period of four consecutive frames, in exactly the same way as the reference pattern

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71 consisting of the state of the channel during the last four frames preceding the current analysis window 70. A decision is then taken to compress the repeated pattern.

The compression device 301' according to the INV1 invention, shown in figure 14, is analogous to the device 301 from figure 7, except for a memory 34' for storing L*N current frames forming the analysis window 70 and a memory 35' for storing N frames preceding the analysis window forming the reference pattern.

Similarly, the device 302' in figure 15 is analogous to that from figure 11, except for the substitution for the memory 51 of a memory 51' for storing the reference pattern (the last four data frames preceding the current compressed frame).

The process is then identical to the process of the priority application explained above:

- on the compressor side, suppression of the static channels from the current window, transmission to each analysis window of the state code ACD specifying the position of each active channel in the entry frame, followed by the concatenated content of each active channel;

- on the decompressor side, extraction/detection of the state code ACD by the detector 49, and then reconstitution of the structure of the uncompressed frame by inserting the content of each active channel at the position specified by the state code ACD, with repetition for each static channel of the content of its corresponding static bit taken from the reference pattern (new process, instead of retaining the reference bit of the static channel considered), thanks to the comparison/storage of the content of the N last frames preceding the change of the channel to the static state. The reference pattern is transmitted periodically between two blocks of data 44'.

We turn now to a particularly advantageous aspect of the INV1 invention that responds to the requirement to secure the method of recovering concatenated channels transmitted in serial form.

A problem can arise following a serialization or sequencing error, reflected in an offset of the data transmitted, to the right if channels declared non-active have been inserted in error, or to the left if channels declared active have not been inserted.

Figure 16 shows a frame structure 44' compressed according to the compression method of the INV1 invention starting from a set 500 of NT frames E1 and supplying at the output end of the system, on the decompressor side, the NT

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frames E1:

This structure begins conventionally with at least one synchronization byte 446 and terminates with stuffing bits 447.

If the device is operating correctly, the number of bits in the concatenated active channels (CAC) field 441' is equal to the number of bits at 1 in the state code, characterizing the position of the active channels within the input frame, multiplied by the number NT of frames in the analysis window.

For example, if ACD = 0 1 0 1   1 1 0 1 (binary) with five bits at 1, meaning that five channels are active for the current analysis window, and if NT = 16, meaning that the analysis window covers 16 input frames at the level of the compressor, then the number of bits in the CAC field is equal to $5 \times NT = 80$ bits; the device compares the eight bits of the frame received, situated 80 bits after the end of the ACD CRC 445; if no formatting or transmission error has occurred, the field obtained in this way is equal to the value established by a delimiter 448 just after the CAC.

However, the delimiter that fixes the boundary between the concatenated active channels and the stuffing bits may be offset from the position it should occupy.

Several errors are possible, induced by binary errors induced at the level of the ACD, the ACD CRC, or the delimiter.

To detect and deal with this kind of situation, which could be the result of a decompression error, various actions are taken, all based on analyzing the content of the delimiter of the received compressed frame (received immediately after the concatenated active channels field as used from the received ACD) and on exploiting the ACD CRC field to detect an error in the transmission of the ACD (or in the CRC associated with the ACD).

The delimiter has a fixed value, set on the compressor side, and equal to 1111 0000, for example.

All the above situations are processed successively by calculating the CRC associated with the ACD, comparing the calculated CRC with the ACD CRC received, and comparing the field received after the concatenated active channels field with the value fixed for the delimiter, using the following method:

- normal situation: if the ACD CRC and the delimiter are correct, decompression is effected using the ACD received;

- if the ACD CRC is incorrect but the delimiter is correct ("ACD CRC error"), decompression is effected using the ACD received;

- if the ACD CRC is correct but the delimiter is incorrect ("delimiter error"), decompression is effected using the ACD received;

- if the ACD CRC and the delimiter are both incorrect, a test is carried out to detect if the field of the delimiter is correct, based on the ACD of the preceding compressed frame (changes of channel activity are generally much less frequent than the period of the compressed frames); if the test result is positive ("ACD error"), decompression is effected using the ACD of the preceding compressed frame; if the test result is negative ("decompression error"), decompression is suspended and the output frames are empty.

From this point on, the description relates directly to the spirit of the invention of the present application.

The principle of the invention, which is obviously related to what has been described hereinafter in that channels can be found to be static in their respective contents, can be summarized as follows:

When a channel goes from the active state to the static state, compression of the channel is deferred by one or more windows; conversely, immediately it becomes active again, the compression process for static channels is eliminated immediately.

This time-delay between the non-activity of the channel and its compression allows a statistical analysis of the state of each of the bits, with a view to reconstituting a reference pattern free of errors and characterizing the transmission error rate precisely; if the error rate increases, the time-delay expressed as a number of analysis windows between the changing of the channels to the static state and their effective compression is increased automatically, to increase the tolerance to transmission errors.

How the present invention works is described in more detail below:

The active channel descriptor (ACD) 442' is always representative of what is in transit between the compressor and the decompressor; in other words, if the channel has just gone to the static state but has not yet been compressed in accordance with the INV1 invention, the ACD bit corresponding to that channel signals that the channel is active, since the content of the channel continues to be transmitted to the decompressor.

Figure 18 is a diagram showing the sampling period of the reference pattern and its transmission in the system, the successive states of a given channel, and the times at which the INV1 compression process is triggered in accordance with INV1.

Note firstly the analysis windows F1 to F6 in temporal sequence. Note that

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the reference pattern 71 is transmitted between the analysis windows 70.

A channel C is estimated to be active during a first period up to a time t_0. The channel C then becomes static until a time t_1, at which it returns to the active state.

5 The bottom line translates the transmission of the content of the channel in the ACD as a function or its active or non-active state.

As explained above, if the channel C becomes static during the window F2, it is compressed (i.e. not transmitted) from the window F3 until the window F6 (time t_2), during which the channel becomes active again (at time t_3).

10 This is in accordance with the INV1 invention.

Figure 19 shows the same diagram in the case of the present invention.

Note accordingly that in figure 19 the content of the static channel has been repeated throughout a supplementary analysis window (the window F3), whereas the channel has become static during the window F2. This means that the channel that has become static is transmitted anyway in the next analysis window (F3) in the ACD and the CAC. On the decompressor side, this modification allows a bit by bit statistical analysis for reconstituting the original 0 or 1 state of each bit carried by the static channel, thus circumventing the effect of disturbed transmission; to this end, the 0 or 1 state of the bit that has come back most often for the bit considered throughout the analysis window (the window F3 in this example) is retained. In one particular embodiment, and in order to increase slightly the accuracy of this mechanism, the state of each bit during the last N frames preceding the current window is also taken into account in the statistical analysis process (71 in figure 13), the effect of which is to increase slightly the number of frames taken into account in the statistical analysis process.

Figure 20 shows an embodiment of the statistical analysis as effected in accordance with the invention using a set of counters, figure 21 shows the evolution of one of the counters during the period without transmission errors on the associated channel, and figure 22 shows the evolution of the same counter with two transmission errors on the channel. The statistical analysis is performed in the following manner:

Let M denote the number of compressed channels in a frame E1; the size of the reference pattern being N bits, a total of M x N counters are used (N is the number of frames contributing to the composition of the reference pattern).

Each of the M x N counters is reset to 0 at the start of the reference pattern preceding the analysis window considered. Accordingly, in figure 20, the counter

cptr1 is set to 0 at the start of the analysis window 70 and is associated with the fourth bit (b1) of the group 700.

The state of each bit received in the group 700 of N bits (N=4 in figure 20) corresponding to the channel considered is exploited and a convention explained

5   below is applied to the bit b1, for example:

if the bit b1 received on the decompressor side = 1, the counter cptr1 is decremented by 1

if the bit b1 received on the decompressor side = 0, the counter cptr1 is incremented by 1

10   and each counter is exploited on leaving the current window, using the following principle:

- let X denote the final value of the counter cptr1,

- the most significant bit of X is taken as the result; if it is at 1, this means that the result of the counter cptr1 is negative, that decrementing has been applied more often than incrementing, and thus that more 1 bits than 0 bits have been

15   received for the bit b1 considered, and conversely for state 0, resulting from majority incrementations,

- if no bit received has been affected by errors (or exceptionally - and highly improbably if all the bits have been tainted with the same inversion of each bit), the

20   absolute value $|X|$ of the result from the counter is equal to the number of frames NT constituting the compression window,

- by extrapolating this principle, if errors have occurred during transmission, the number of errors is $Ne = (1 + (NT / N) - |X|) / 2$, where N is the number of frames contributing to the constitution of the reference pattern.

25   Figure 20 shows the counting graph established for N = 4 and NT = 16.

- the bit b1 having the value 0 in the first group 700, the counter cptr1 takes the value 0 + 1 = 1, in accordance with the above convention,

- the bit b1 having the value 1 in the second group 700, the counter cptr1 takes the value 1 - 1 = 0,

30   - the bit b1 having the value 0 in the third group 700, the counter cptr1 takes the value 0 + 1 = 1,

- the bit b1 having the value 0 in the first group 700, the counter cptr1 takes the value 1 + 1 = 2.

This result in binary is 0.. 0010, the most significant bit representing the final

35   state of the bit, i.e. its sign.

According to the same principle, the bit b2 is equal to –2 at the end of the window and the result in binary is therefore 1.. 0010.

Figure 21 shows the counting graph established by taking N = 4 and NT = 32; the bits of the reference pattern are respectively denoted a, b, c, d, and what is of interest is the evolution of the counter X associated with the bit d, firstly without transmission errors (in this example the bit d is taken as equal to 0).

d represents the state of the bit d received. With no transmission errors (figure 21), after the window considered, the value of the counter X is 9, signifying that d = 0 (value of the sign bit of the counter X) and that:

$1 + (NT / N) - |X| = (1 + (32 / 4) – 9) / 2 = 0$, signifying that no transmission error has been detected.

Figure 22 shows the counting graph with two transmission errors during the window considered.

After the window considered, the value of the counter X is 4, signifying that d = 0 and that:

$1 + (NT / N) - |X| = (1 + (32 / 4) – 5) / 2 = 2$, signifying that two transmission errors have been detected.

This therefore amounts to a majority vote method of deciding if each bit considered individually is equal to 1 or to 0, based on statistics accumulated during the analysis window, on the decompressor side.

More than half the bits received would have to be erroneous, i.e. there would have to be five erroneous bits in this example, for the device to output the wrong value of the reference bit; for up to four erroneous bits, the device outputs the correct value of the reference bit, indicating that four errors have been detected.

The maximum number of errors detected is fed back continuously to the compressor, in order to adjust the number of windows taken into account in this method of transmitting static frames on the channel changing from the active state to the static state. The requirement to transmit more than one window corresponds to uses of the connection in very degraded mode, a single window having conditions for recovery of reference bits that are more than sufficient under normal conditions of use of a connection. Nevertheless, this constitutes a very effective means of adapting the compression overhead (header field) as a function of the quality of the link.

If compression is applied in this mode, in which the number of windows used for the transmission of the refer nce pattern varies as a function of the quality of the connection, information is integrated into the header of each compressed frame,

specifying the number of windows currently used for the repetition process: 0 if the error rate measured by the demodulator associated with the decompressor on the connection is less than a given threshold, for example 10^{-8}, or 1 if the error rate measured by the modem exceeds the reference threshold, after which the number of windows is increased by 1 each time that the error rate measured in accordance with the principle just explained exceeds x% of the value NP/N, for example 25%; this global principle constitutes an advantageous embodiment.

Of course, the present invention is not limited to the embodiments described and other embodiments of the invention can easily be envisaged by the person skilled in the art.